Biomass Co-Firing for Pulverized Coal Combustion Applications

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Abstract

FETC's pilot-scale 500,000 Btu/hr Combustion and Environmental Research Facility (CERF) is investigating biomass co-firing issues in pulverized coal (pc) units. Technical issues include biomass fuel handling/processing, and biomass impacts on flame stability, combustibility, ash deposition, and emissions.

This project is funded from FETC's Coal Utilization Science Program to acquire basic combustion data to interpret and model results with the broad goal of assisting utility biomass co-firing demonstrations. FETC has a heavily industry-cost shared Cooperative Agreement with the Electric Power Research Institute (EPRI) for biomass co-firing utility demonstrations.

Biomass fuels include locally available waste materials, such as sawdust and wood chips from lumber mills, agricultural and forest residues, utility right-of-way residues, pallets, and nonrecyclable paper. Biomass also includes energy crops, such as fast growing grasses and short rotation woody trees that could be harvested specifically as boiler fuel.

Principal driving forces for biomass include the broad-based efforts to encourage renewable energy and reduce fossil energy emissions of CO_2 as well as SO_2 and NO_x. Biomass combustion is seen as a means of closing the carbon cycle, as in effect, solar energy (photosynthesis) is converted to thermal energy. Some utilities' interest in biomass seeks to reduce costs and/or form strategic activities with large industrial customers, be good neighbors to the community, or as part of "green pricing" programs. Because the U.S. has considerable acreage of erodible soils that are being phased out of a federal subsidy program, certain states are examining energy crops, such as switchgrass, as a potential option for generating revenue. Several organizations are also interested in the improved habitat for birds that results from the tall switchgrass.

Traditionally, biomass-only boilers have not been very efficient, primarily due to high moisture and fuel handling, as well as high alkali contents that force lower steam temperatures. Biomass-only plants tend to be smaller than pc boilers based on fuel transportation costs (which do not favor low energy density biomass fuels) which also impacts net boiler efficiencies, as small solid fuel-fired boilers generally have higher heat rates from less elaborate turbine systems and higher parasitic power requirements relative to large boilers.

Biomass co-firing within the existing infrastructure of pc utility boilers is viewed as a practical means of encouraging renewable energy while minimizing capital cost requirements and maintaining the high efficiencies of pc boilers. The wide dispersion of pc boilers (in number and capacity) translates into significant potential opportunities for biomass utilization, even at levels of only 5-15% of the thermal input. While biomass co-firing in pc boilers appears promising, it does have risks, including some that are not obvious. Most important is the recognition that coal-fired boilers must underpin co-firing, which requires integration of biomass into utilities core business (coal) in terms of boiler operations, including heat rate, availability and capacity, emissions, ash salability, and other operations & maintenance (O&M) factors that impact the net cost-of-electricity. This project seeks to identify methods and criteria to help determine which types of interactions might occur in a specific application.

A portion of the CERF biomass co-firing test program is being jointly conducted with researchers at Sandia National Laboratories (SNL) and the National Renewable Energy Laboratory (NREL). While the CERF conducts long term tests, SNL and NREL can acquire more fundamental data (e.g., relating to kinetics) and perform 100% biomass comparison tests. SNL is utilizing its 100,000 Btu/hr Multi-Fuel Combustor, while NREL is performing bench-scale studies using its gas chromatograph/molecular beam spectrometer with a small fixed-bed reactor. SNL is also developing combustion models to examine biomass particle size and moisture considerations for various boiler parameters. Together, the joint FETC/SNL/NREL effort is providing a comprehensive understanding of biomass co-firing impacts, particularly when coupled with data from utility co-firing demonstrations.

The CERF testing includes three coals - Pittsburgh and Eastern Kentucky bituminous and Wyoming Powder River Basin subbituminous - with biomass fuels such as switchgrass, hybrid willow, alfalfa stems, wood chips/sawdust, and nonrecyclable paper. Collectively, these fuels cover a wide range of key characteristics, such as heating value, proximate and ultimate analysis, ash composition (e.g., alkali) and ash fusion temperature profiles.

Another project involves collaboration with Energy and Environmental Research (EER) Corporation to evaluate biomass reburning, including advanced reburning processes where sodium and ammonia-type injection are used to increase NO_x removal. This project involves joint funding between FETC and the U.S. Department of Agriculture.

Because biomass fuel handling (size reduction and injection) is a key issue, the FETC activities involve evaluation of prototype and/or specialized mills, including mills that have been developed for other commercial applications. These activities are conducted through various arrangements, including Cooperative Research & Development Agreements (CRADAs), to obtain combustion data for biomass fuels that are processed through novel mills. Included are efforts aimed at co-pulverization of coal and biomass.

Upcoming tests will evaluate creosote-treated and pentachlorophenol-treated transmission poles. Stack sampling of trace organics (e.g., dioxins, furans) will be conducted to demonstrate that such treated woods can be successfully co-fired without adverse environmental impacts.